Measuring Social Costs of Inefficient Combination of Policy Instruments The Case of the U.S. Agricultural Policy

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MEASURING SOCIAL COSTS OF INEFFICIENT COMBINATION OF POLICY INSTRUMENTS - The Case of the U.S. Agricultural Policy

David S. Bullock and Klaus Salhofer*

ABSTRACT

Since most agricultural programs employ two or more policy instruments simultaneously, it is notable that little research exists which evaluates the social costs of combining instruments imperfectly or attempts to find optimal instrument combinations. This study provides the first formal approach to measure the social costs of inefficient combination of policy instruments. The formal approach is applied to analyze the efficiencies of government policies for five major U.S. crops (corn, feed grains, wheat, rice, cotton). Our simple models suggest that except for the feed grains program, the observed programs combined policy instruments quite imperfectly. The social costs of inefficient instrument combination for all five crops are estimated to be either US $1,733 million in terms of potential welfare gains of farmers or US $1,911 million in terms of potential welfare gains of nonfarmers. We conclude that agricultural research should place increased emphasis on finding efficient combinations of policy instruments.

ABRISS

Da die meisten Agrarmarktinteventionen zwei oder mehrere Politikinstrumente gleichzeitig einsetzen, ist es erwähnenswert, daß wenige Forschungsarbeiten die sozialen Kosten von unvollkommen kombinierten Instrumenten bewerten oder versuchen optimale Instrumentenkombinationen zu finden. Diese Studie liefert den ersten formalen Ansatz um die sozialen Kosten von ineffizienten Instrumentenkombinationen zu messen. Dieser formale Ansatz wird angewendet um die Effizienz der staatlichen Politik in Hinsicht auf fünf der wichtigsten Anbauprodukte der USA zu untersuchen. Unser einfaches Model zeigt, daß außer im Fall von Futtergetreide die Instrumente sehr unvollkommen kombiniert wurden. Für alle

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fünf Anbauprodukte gemeinsam werden die sozialen Kosten der ineffizienten Instrumentenkombination auf US $ 1,733 Millionen, bezogen auf die möglichen Wohlfahrtsgewinne der Landwirte, und auf US $ 1,911 Millionen, bezogen auf die möglichen Wohlfahrtsgewinne der Nichtlandwirte, geschätzt. Wir folgern, daß die agrarwirtschaftliche Forschung verstärkt versuchen sollte, effiziente Instrumentenkombintationen zu finden.

INTRODUCTION

Since Wallace, many studies have attempted to measure the social costs of agricultural programs using economic welfare measures. Most of these studies investigate the social costs caused by suggested or existing programs (e.g. Dardis; Veeman; Longworth and Knopke; Cramer et al.; Albiac and Garcia; Nardone and Lopez), or compare the efficiencies of alternative policy options (Leu, Schmitz and Knutson; de Gorter and Meilke; Babcock, Carter and Schmitz; Sarwar and Fox; Kola; Myneni et al.). Since most agricultural programs simultaneously employ two or more policy instruments,[1] it is notable that little research exists which attempts to find optimal (efficient) instrument combinations or evaluates the social costs of combining instruments inefficiently. Very recently some papers discuss the issue of combining instruments optimally: Gardner calculates the optimal combination of research spending and price supports for the U.S. grains sector. Maier discusses how the optimal mix of instruments changes with respect to changes in demand elasticities and export shares. Alston, Carter and Smith as well as Moschini and Sckokai discuss theoretically the efficient combination of export subsidies and output subsidies as well as the efficient combination of tariff and direct payments. Salhofer and Bullock (1995) were the first to attempt to measure the social costs of imperfect instrument combinations. Salhofer illustrates for the Austrian bread grains market that the costs to consumers and taxpayers could be reduced significantly by implementing currently used instruments optimally. Bullock (1995) demonstrates for EC wheat policy that the actual welfare outcome was not efficient.

In this paper we provide the first formal approach to measure the social welfare costs of inefficient combination of policy instruments by adapting Bullock's (1994) general model of income redistribution to this specific problem. We illustrate our method for five major U.S. crops (corn, feed grains, wheat, cotton, and rice) utilizing a model recently used by Gisser. We show that the social costs of imperfect instrument combination might be quite high. Therefore we argue that future research should place increased emphasis on finding optimal combinations of instruments, rather than simply comparing the efficiencies of different instruments or programs.

A FORMAL APPROACH

Following Bullock (1994), the general case of society's welfare distribution caused by government intervention may be modeled with a government using m policy instruments to change the welfare of n social groups. Let $\mathbf{x} = (x_1, \ldots, x_m)$ be a vector describing levels of policy instruments 1, . . . , m which government is observed to use.[2] For example, x_1 might be a target price, x_2 might be an acreage retirement requirement, x_3 might be an import quota, etc. A particular value of the variable vector **x** is called a policy. Let X be the set of all policies that can be implemented given limited resources and call it the set of technically feasible policies.[3] Let $\mathbf{u} = (u_1, \ldots, u_n)$ be a vector describing welfare levels of all n social groups 1, . . . , n, affected by government policy. Social groups might be wheat farmers, income taxpayers, tractor producers, etc.[4] Let $\mathbf{b} = (b_1, \ldots, b_z)$ be a vector of exogenous market parameters. Examples of elements of vector **b** might be supply and demand elasticities, as well as parameters describing weather and technology. Let B be the set of all physically possible parameter vectors **b**. Group welfare levels are functions of market conditions and government policy:

$$\mathbf{u} = (h_1(\mathbf{x},\mathbf{b}), \ldots, h_n(\mathbf{x},\mathbf{b})) = \mathbf{h}(\mathbf{x},\mathbf{b}). \tag{1}$$

where function $\mathbf{h}$ is continuously differentiable on $X \times B$.

If market conditions can be described by $\mathbf{b^1} \in B$ we get a set of technically feasible welfare outcomes:

$$F(\mathbf{b^1}) = \{\mathbf{u} \mid \mathbf{u} = \mathbf{h}(\mathbf{x},\mathbf{b^1}),\ \mathbf{x} \in X\}, \tag{2}$$

which is a min{m, n}-dimensional submanifold in R^n. $F(\mathbf{b^1})$ contains all welfare outcomes that government could technically achieve by combining the actually used instruments at all possible levels. The shaded area in Figure 1 illustrates such a feasible set for the case of n = 2 and m > 1.

Figure 1

Given the actual policy $\mathbf{x^1} \in X$ we can obtain the actual policy outcome $\mathbf{u^A}$

$$\mathbf{u^A} = (u_1^A, \ldots, u_n^A) = (h_1(\mathbf{x^1},\mathbf{b^1}), \ldots, h_n(\mathbf{x^1},\mathbf{b^1})) = \mathbf{h}(\mathbf{x^1},\mathbf{b^1}), \tag{3}$$

which is a point in R^n, e.g. point A in Figure 1.

An instrument combination $\mathbf{x^*}$ is optimal or efficient in a Pareto sense, if for any i = 1, . . . , n it solves the constrained maximization problem: [5]

$$\max_{\mathbf{x} \in X} h_i(\mathbf{x},\mathbf{b^1}) \quad \text{s.t.} \quad h_j(\mathbf{x},\mathbf{b^1}) \geq h_j(\mathbf{x^1},\mathbf{b^1}) \quad j = 1, \ldots, i-1, i+1, \ldots, n, \tag{4}$$

and $\mathbf{x}$ is assumed to be a unique solution.

A proof for this is provided in the Appendix. Let XE($\mathbf{b^1}$) be the set of efficient policies, then the set of welfare outcomes obtained from efficient policy instrument combinations is described by

$$P(\mathbf{b^1}) = \{\mathbf{u} \mid \mathbf{u} = \mathbf{h}(\mathbf{x},\mathbf{b^1}), \mathbf{x} \in XE(\mathbf{b^1})\}. \quad (5)$$

The "northeast" boundary of the shaded area in Figure 1, the Pareto frontier, shows such a set of welfare outcomes obtained from efficient instrument combinations. As long as the actual welfare outcome is not an element of P($\mathbf{b^1}$) it is possible to combine instruments in a way that improves the welfare of at least one group without decreasing the welfare of all other groups. For example in Figure 1 the government could improve the welfare of group 1 to point B leaving group 2 at its actual welfare level, by selecting the policy the outcome of which is point B. Point B, which is an element of P($\mathbf{b^1}$) can be found by solving equation (4) for i = group 1, j = group 2.

The social costs of inefficient combination (SCIC) of policy instruments in terms of potential welfare gains of group i can be measured by

$$SCIC_{u_i} = u_i^* - u_i^A = h_i(\mathbf{x}^*, \mathbf{b^1}) - h_i(\mathbf{x^1}, \mathbf{b^1}), \quad (6)$$

where $u_i^* = h_i(\mathbf{x}^*, \mathbf{b^1})$ is the unique solution to equation (4). Hence, in Figure 1 distances AB and AC measure the welfare costs of imperfect combination of the actually used instruments in terms of potential welfare gains of group 1 and group 2, respectively.

EMPIRICAL EXAMPLE

We will now illustrate this general procedure for the case of five major U.S. crops (corn, feed grains, wheat, rice, and cotton). To do so we utilize a simple partial equilibrium model recently developed by Gisser.[6] In this model production of an agricultural commodity is described by a CES-production function :

$$Q = Z(\alpha A^{-\rho} + \beta B^{-\rho})^{-\frac{1}{\rho}}, \tag{7}$$

where Q denotes the quantity of an agricultural product, Z a shift parameter, B the land used for production, A encompasses all other inputs, and α, β, and ρ are production function parameters. Because land is considered to be fixed, either by government or by nature, and the input price of the variable factor (P_a) is constant throughout the analysis, the production function can be immediately inverted to obtain a derived conditional demand function for input A. The fixed factor is assumed to be owned by the firm. Total variable costs of production equal the cost of the purchased factor, $C = AP_a$. The first derivative of the cost function with respect to Q gives us the marginal cost function or the short run supply function:

$$P = \alpha^{\frac{1}{\rho}} P_a Z^{\rho}\left(Q^{-\rho} Z^{\rho} - \beta B^{-\rho}\right)^{-\frac{1+\rho}{\rho}} Q^{-(1+\rho)}, \tag{8}$$

where P denotes the supply price.

Total (domestic plus the rest-of-world excess) demand is described by the constant elasticity demand function:

$$Q = HP_d^{\eta}, \tag{9}$$

where η, H and P_d are the price elasticity of demand, a shift parameter and the world market as well as the domestic demand price. Domestic demand is given by:

$$Q_d = (1 - E)HP_d^{\eta}, \tag{10}$$

where Q_d is the domestic quantity demanded, and E denotes exports as a proportion of total production.

Equation (7) through (10) describe an agricultural commodity market. Market parameters are $\mathbf{b} = (\alpha, \beta, \rho, Z, H, P_a, \eta, E)$. We are able to describe the five agricultural commodity markets under investigation by applying the specific market parameters $\mathbf{b^1} = (\alpha^1, \beta^1, \rho^1, Z^1, H^1, {P_a}^1, \eta^1, E^1)$ to equations (7) through (10). According to Gisser the production parameters $(\alpha^1, \beta^1, \rho^1)$ are assumed to be equal for all commodities (0.763, 0.237, 5.0976). Z^1, and H^1 are set to one, and ${P_a}^1$, η^1, E^1, are reported in Table 1 for all commodities. For example, in the case of corn $\mathbf{b}_c^{\mathbf{1}} = (\alpha^1, \beta^1, \rho^1, Z^1, H^1, P_{ac}^1, \eta_c^1, E_c^1)$ = (0.763, 0.237, 5.0976, 1, 1, 0.9774, -0.75, 0.224).

Table 1

The model of equations (7) through (10) is represented graphically in Figure 2, where S_0 and D_d denote domestic supply and demand curves. Curve D is the domestic plus rest-of-world excess demand. The horizontal difference between D and D_d is therefore the export share E. In a free market, without government intervention, $P = P_d$, and equilibrium would be determined at point G, where supply intersects demand and equilibrium price (P_e) and quantity (Q_e) are realized.

Figure 2

For simplicity we investigate the combination of two major instruments of U.S. agricultural policy (target price and acreage control).[7] In order to receive the target price P farmers have to idle land as required by the acreage reduction program. Because of this constraint on the production factor land, production costs rise and the supply curve pivots from S_0 to S_1. The combined use of these two instruments leads to an output of Q and a world market price of P_d. The target price (P) and the acres of land used for production (B) are policy instruments in the model (7) through (10), and therefore **x** = (B,P) in this empirical example. Following Gisser, B, A, Q, and P_d are initially set to one. Since in the case of corn the target price P is 28.1 percent higher than the market price P_d (Table 1, column 4) the actual instrument vector for corn is described by $\mathbf{x}_c^1 = (B_c^1, P_c^1)$ = (1,1.281). Instrument vectors for all other crops are defined in the same way.

The market intervention increases the welfare of producers and consumers but decreases taxpayer welfare. For illustrative purposes we divide the society into two groups, farmers and nonfarmers. The welfare of farmers is measured by producer quasi-rents (PS) which are given by revenues minus costs:

$$PS = PQ - P_a A. \tag{11}$$

Welfare of nonfarmers is measured by consumer surplus (CS) minus taxpayer's costs (T). CS is calculated by:

$$CS = \frac{(1-E)H}{\eta+1}\left[\gamma^{\eta+1} - P_d^{\eta+1}\right], \tag{12}$$

where γ denotes the point where the demand curve intersects the price axis.[8] T is given by the difference between target price and market price times quantity supplied

$$T = \left(P - P_d\right)Q. \tag{13}$$

The vector of welfare levels **u** = (CT,PS) = ($h_{CT}(\mathbf{x},\mathbf{b})$, $h_{PS}(\mathbf{x},\mathbf{b})$), where

$$CT = CS - T. \tag{14}$$

Welfare outcomes for each commodity can be calculated by employing the specific market parameters $\mathbf{b^1}$ and a particular value of the variable **x** in equations (7) through (14).

In the case of corn the set of feasible policy outcomes is given by

$$F\left(\mathbf{b}_c^{\mathbf{1}}\right) = \left\{(CT,PS) \middle| (CT,PS) = \left(h_{CT}\left(\mathbf{x},\mathbf{b}_c^{\mathbf{1}}\right),\ h_{PS}\left(\mathbf{x},\mathbf{b}_c^{\mathbf{1}}\right)\right)\right\} \tag{15}$$

and the actual policy outcome by

$$\mathbf{u}^A = (CT,PS) = (h_{CT}(\mathbf{x}_c^{\mathbf{1}},\mathbf{b}_c^{\mathbf{1}}), h_{PS}(\mathbf{x}_c^{\mathbf{1}},\mathbf{b}_c^{\mathbf{1}})) = \left\{33721, 4796\right\}, \tag{16}$$

which can be calculated by using values $\mathbf{b}_c^1$ and $\mathbf{x}_c^1$ in equations (7) through (14). The welfare of nonfarmers is calculated to be US $33,721 million, whereas farmers' welfare is US $4,796 million.[9] The actual welfare outcomes for all other crops are calculated similarly appear in Table 2 column 1 and 2.

Table 2

According to equation (4) we can calculate the maximum welfare available to corn farmers leaving nonfarmers at their actual level by solving the constrained maximization problem

$$\max_{\mathbf{x}_c} \mathrm{h}_{PS}(\mathbf{x}_c, \mathbf{b}_c^1) \quad \text{s.t.} \ \ \mathrm{h}_{CT}(\mathbf{x}_c, \mathbf{b}_c^1) \geq 33721. \tag{17}$$

We solved such a maximization problem using GAMS software (Brooke, Kendrick and Meeraus). The maximum welfare corn farmers can reach, given that the welfare of nonfarmers will not decrease below the actual level of US $33,721 million, is US $5,139 million (column 3 in Table 2). The social costs of inefficient implementation of the actual used instruments are US $5,139 - US $4,796 = US $343 million in terms of potential welfare gains of farmers (column 5 in Table 2). The maximum welfare nonfarmers can reach, given that the welfare of corn farmers will not decrease below the actual level is US $34,110 million and hence the social costs of inefficient instrument implementation are US $389 million in terms of nonfarmer welfare. Table 2 also reports that the costs of imperfect combination are also considerably high for all other crops, except feed grains. The total social costs of inefficient instrument combination for all five crops are calculated to be US $1,733 in terms of potential welfare gains of farmers and US $1,911 in terms of potential welfare gains of nonfarmers.

DISCUSSION

Many studies have valued the social costs of actual or suggested agricultural programs or have compared the costs of alternative policies. Less research has attempted to answer the question of how costly inefficient combinations of policy instruments are or what the optimal combination would be. In this paper we provide a formal approach of how to value the social costs of inefficient combination of policy instruments. Based on the concept of Pareto optimality, the social costs are expressed in terms of the potential welfare gains of one of the social (or interest) groups affected by the agricultural policy. By utilizing an agricultural model recently used by Gisser we were able to value the social costs of imperfect instrument combination for five major U.S. crops. Our research suggests that, except for feed grains, the actually used instruments were combined quite inefficiently, and that therefore the social costs of actual policy were quite high. Hence, we argue that agricultural research should place increased emphasis on finding the optimal combination of policy instruments.

NOTES

[1]Examples are manifold like the combination of import quotas and production controls in the Canadian dairy and poultry sector, the combination of target prices, loan rates and acreage controls for main U.S. crops or the combination of voluntary set-asides with compensation payments under the EU's new arable regime.

[2]We restrict our approach to the problem of the inefficiency caused by imperfect combination of policy instruments actually used. This can be easily generalized to the problem of the inefficiency caused by imperfect combination of policy instruments and use of wrong instruments by assuming that **x** is a vector of all instruments available to the government. Naturally, in such case the question of which instruments are available to the government remains.

[3]Note that a technically feasible policy need not necessarily be politically feasible.

[4]In the extreme case a group might consist of one individual.

[5]In a strict sense applying Pareto optimality to groups instead of individuals implies the assumption that individuals within a group are identical or that lump sum transfers within a group are possible. However, using Pareto optimality in a group context is not unusual in agricultural economics (e.g. Schmitz).

[6]The model is a standard neoclassical model in the tradition of Floyd. Our purpose in employing this simple model is to illustrate our methodology, and not at this point in time to provide definitive answers about whether actual U.S. policies were efficient.

[7]We ignore the loan rate program in this empirical example.

[8]In the case of corn and cotton the demand elasticities are less than one and the demand curves will not meet the price axes. Hence in these cases we assume a certain γ.

[9]By setting Q and P_d to unity it is implied that the market value of output (P_dQ) of each commodity is unity, too. Therefore, to get the reported dollar values of farmers' and nonfarmers' welfare we have to multiply the results of equations (16) and (17) by the market value of output. Average annual market values of output for each commodity are taken from Gisser and reported in Table 1 column 5.

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APPENDIX:

Prove: Let **x*** be a unique solution to

$$(1)\ \max_{\mathbf{x}\in X} h_i(\mathbf{x},\mathbf{b}^1) \quad \text{s.t. } h_j(\mathbf{x},\mathbf{b}^1) \geq h_j(\mathbf{x}^1,\mathbf{b}^1) \quad j = 1,\ldots,i-1,i+1,\ldots,n$$

Then **x*** is efficient.

Proof: Suppose not. Then **x*** is a unique solution to (1), but **x*** is inefficient. Since **x*** is inefficient, there exists some **x'** in X such that $h_1(\mathbf{x'},\mathbf{b^1}) \geq h_1(\mathbf{x^*},\mathbf{b^1})$, $h_2(\mathbf{x'},\mathbf{b^1}) \geq h_2(\mathbf{x^*},\mathbf{b^1})$, . . . , $h_n(\mathbf{x'},\mathbf{b^1}) \geq h_n(\mathbf{x^*},\mathbf{b^1})$, where at least one of these n inequalities holds strictly. Since **x*** solves (1), we know that $h_i(\mathbf{x^*},\mathbf{b^1}) \geq h_i(\mathbf{x^1},\mathbf{b^1})$, $h_j(\mathbf{x^*},\mathbf{b^1})_j \geq \mathbf{h}_j(\mathbf{x^1},\mathbf{b^1})$, j = 1, . . . , i-1, i+1, . . . , n. Therefore there are two possibilities:

Possibility 1: $h_i(\mathbf{x'},\mathbf{b^1}) > h_i(\mathbf{x^*},\mathbf{b^1}) \geq h_i(\mathbf{x^1},\mathbf{b^1})$

$h_j(\mathbf{x'},\mathbf{b^1}) \geq h_j(\mathbf{x^*},\mathbf{b^1}) \geq h_j(\mathbf{x^1},\mathbf{b^1})$ j = 1, . . . , i-1, i+1, . . . , n

(that is, the inequality holds strictly for i). But Possibility 1 implies that **x*** is not a solution to (1), which contradicts our original assumption.

Possibility 2: $h_i(\mathbf{x'},\mathbf{b^1}) = h_i(\mathbf{x^*},\mathbf{b^1}) \geq h_i(\mathbf{x^1},\mathbf{b^1})$

$h_j(\mathbf{x'},\mathbf{b^1}) \geq h_j(\mathbf{x^*},\mathbf{b^1}) \geq h_j(\mathbf{x^1},\mathbf{b^1})$ j = 1, . . . , i-1, i+1, . . . , n

(that is, the inequality does not hold strictly for i). But Possibility 2 implies that if **x*** solves (1), so does **x'**, which contradicts our assumption that **x*** is a unique solution to (1). Since both Possibility 1 and Possibility 2 lead to contradictions of our original assumptions, the proof is complete.

By assuming that **x*** is a unique solution for each i we exclude the existence of "perverse" feasible sets like the one represented by the shaded area in Figure A. Again if A is the actual welfare outcome and point B as well as point C are elements of the feasible set. Then point B and point C would be solutions of the maximization problem (1) for i = 2 and j =

1 and hence $h_2(\mathbf{x}^*_B,\mathbf{b^1}) = h_2(\mathbf{x}^*_C,\mathbf{b^1})$. But only C is actually a point on the Pareto frontier since $h_1(\mathbf{x}^*_B,\mathbf{b^1}) < h_1(\mathbf{x}^*_C,\mathbf{b^1})$. Bullock (1995) represents a method for finding Pareto optimal points when the feasible set is possible perverse.

Appendix Figure A

Table 1. Market Parameters of Five Major Crops

	Elasticity of Demand (η^1) (1)	Export Share (E^1) (2)	Input Price of factor A (P_a^1) (3)	Target Price (P^1) (4)	Market Value of Output ($) (5)
Corn	- 0.75	0.224	0.9774	1.281	15,796
Feed Grains	- 1.96	0.159	0.8897	1.166	3,283
Wheat	- 3.00	0.568	1.0117	1.326	6,746
Rice	- 2.20	0.501	1.2948	1.697	907
Cotton	- 0.50	0.412	0.9774	1.281	3,559

Source: Gisser

Table 2. Actual Welfare Distribution, Optimal Welfare Distribution, and Social Costs of Inefficient Instrument Combination

	Actual Welfare Distribution		Optimal Welfare Distribution		Social Costs of Inefficient Combination in Terms of	
	Farmers mill. US $ (1)	Nonfarmers mill. US $ (2)	Farmers mill. US $ (3)	Nonfarmers mill. US $ (4)	Farmers mill. US $ (5)	Nonfarmers mill. US $ (6)
Corn	4,796	33,721	5,139	34,110	343	389
Feed Grains	907	2,016	923	2,034	16	18
Wheat	2,120	-757	2,345	-505	225	252
Rice	365	-279	527	-103	162	176
Cotton	1,081	8,050	2,067	9,126	986	1,076
Total	9,268	42,751	11,001	44,662	1,733	1,911

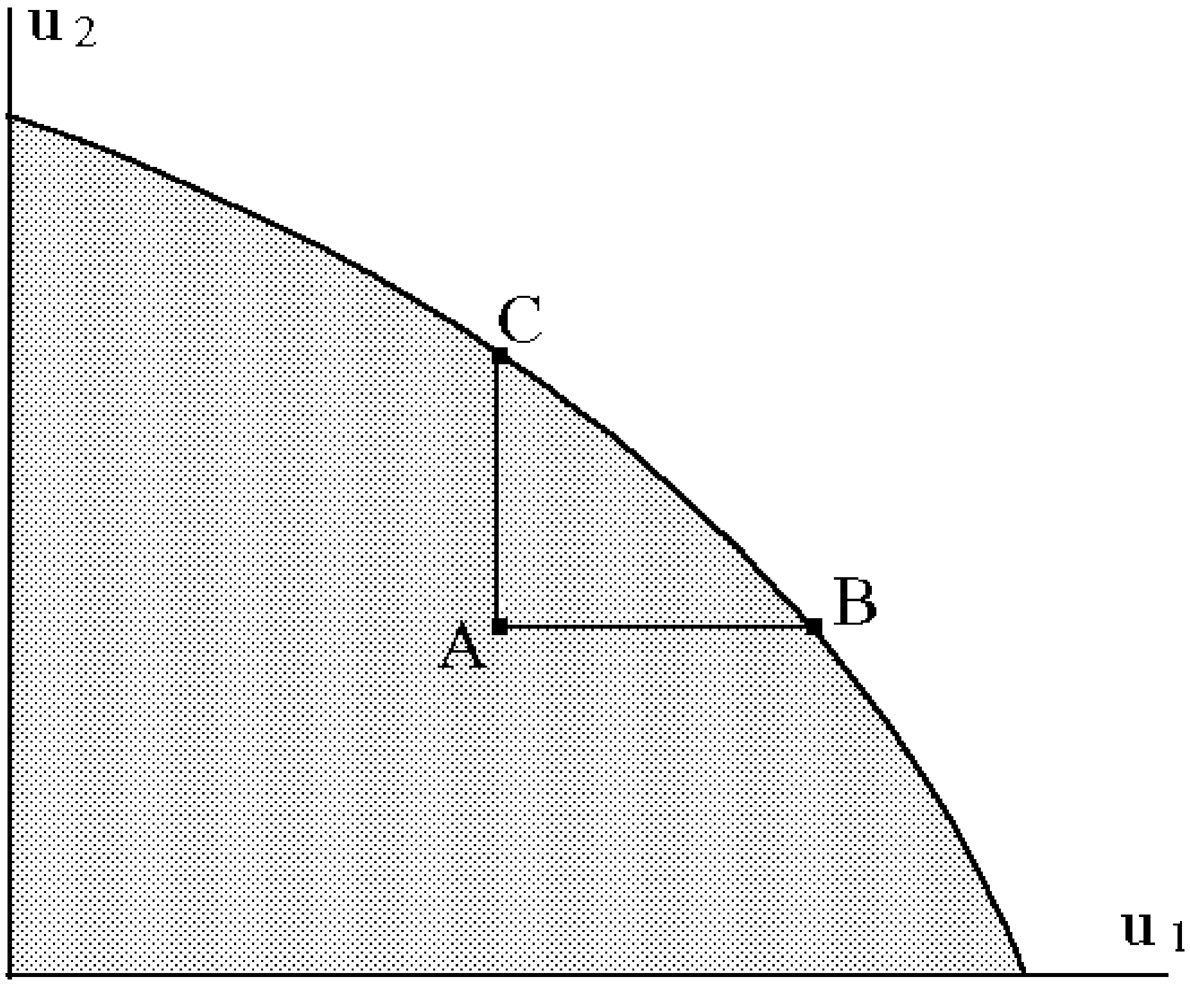


Figure 1. Set of Technically Feasible Policy Outcome, Actual Policy Outcome, and Social Costs of Inefficient Combination of Policy Instruments

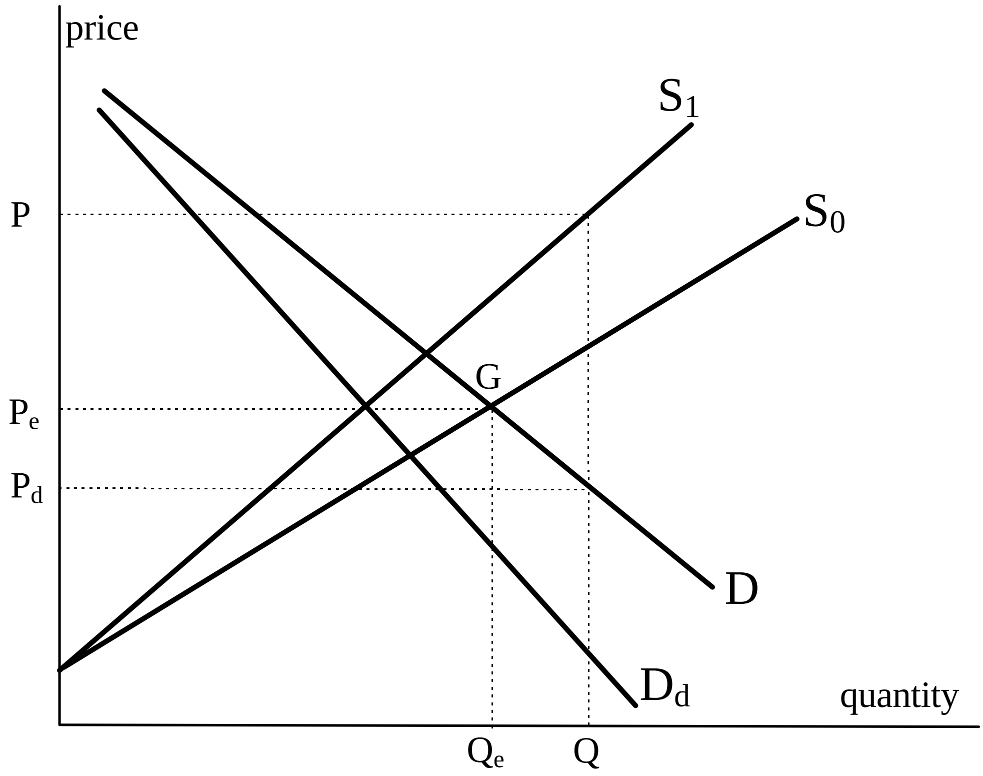
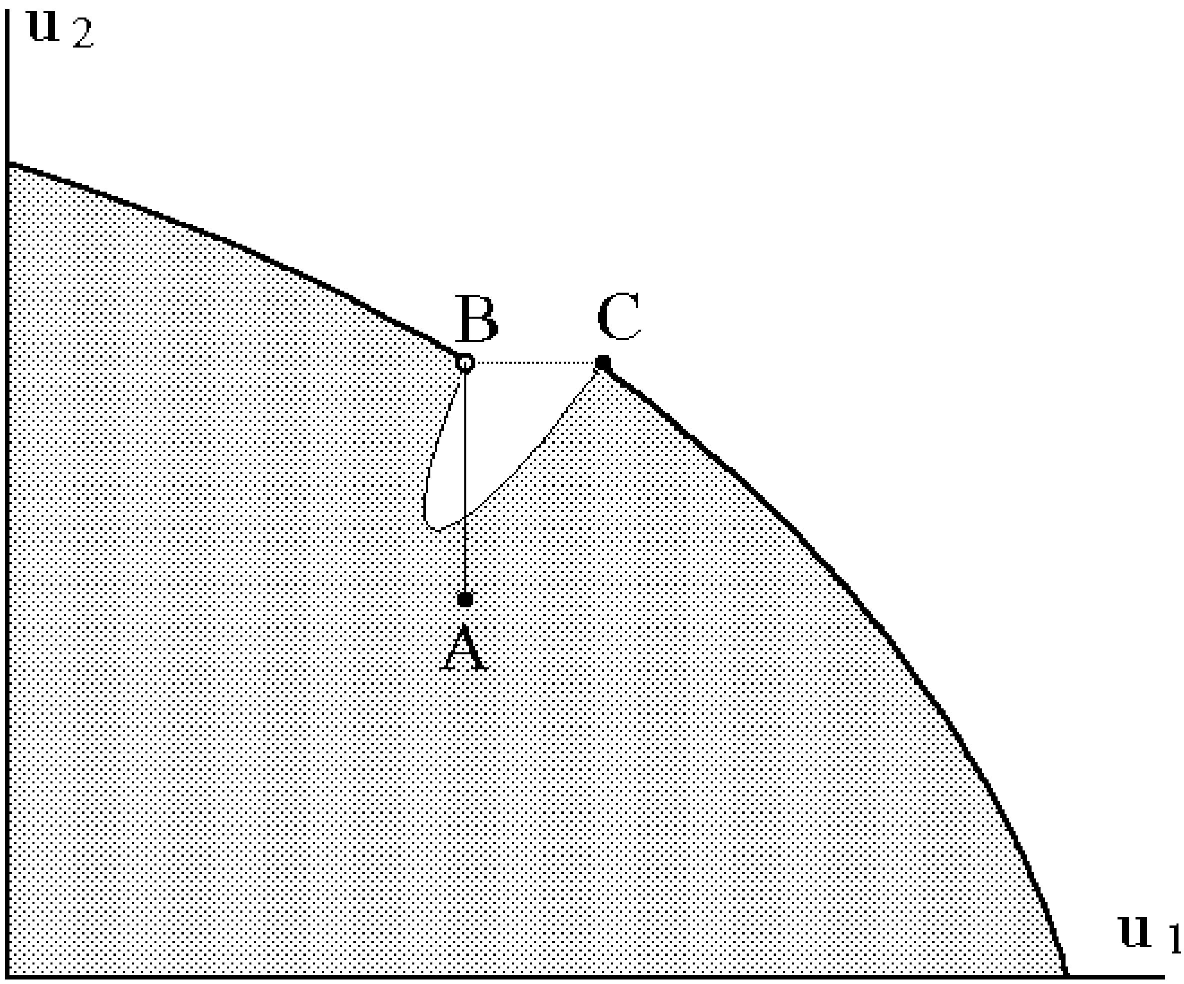


Figure 2. U.S. Agricultural Policy



Appendix Figure A. “Perverse“ Feasible Set

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